Chapter 8
Conveyance and Distribution Systems

Many of the water quality BMPs discussed in this manual rely on conveyance and distribution systems to adequately get the water to the BMP. This chapter discusses some of the more common conveyance and distribution systems including:

- Vegetated Swales
- Flow Splitters
- And Level Spreaders

8.1 Vegetated Swales

IMPORTANT

Swales may only be used for pretreatment and stormwater runoff conveyance. DEP does not approve the use of swales for water quality treatment.

Chapter Contents:

8.1.1 Description

Vegetated swales are broad shallow earthen channels with a dense stand of vegetation. The combination of low velocities and vegetative cover promotes settlement of particulates and some degree of treatment by infiltration. The judicious use of low velocity swales can also help attenuate the volume and peak rate of runoff.

The use of check dams and wide depressions in swales increase runoff storage and promote greater settling of pollutants. Check dams create small infiltration pools along the length of the swale, which are used to retard and temporarily impound runoff to induce infiltration and promote filtering and settling of nutrients and other pollutants.

Because of their limited ability to remove dissolved pollutants, vegetated swales should generally be viewed as pre-treatment systems. Grass filter systems are generally most effective when used in combination with other BMPs. Designers should seriously consider integrating redundant pollutant removal enhancement features such as stilling basins, stone infiltration or low-flow trenches, and check dams into swale systems (Galli, 1993). A typical vegetated swale with check dams is shown in Figure 8-1.

8.1.2 Site Suitability Criteria

1. **Applicability:** Vegetated swales are most applicable in residential or institutional areas where the percentage of impervious cover is relatively small. While swales are generally located along rear or side property lines of residential lots, they are also used along roadways instead of curbs and gutters. Roadside swales become less feasible as the number of driveways requiring culverts for swale crossings increases.

2. **Slopes:** Areas with steep slopes may limit the use of swales. In such areas, swales should parallel the contour, in effect becoming diversions. If the slopes are too steep, the construction of low velocity swale cross sections may involve excessive disturbance of existing grades to provide stable backslopes.

3. **Flow Volume/Velocity:** Vegetated swales are most effective when the flow depth is shallow and the velocities are low.

4. **Using Natural Swales:** Existing channels should only be used when they are shown to conform with the same design requirements that apply to new facilities. Existing ditches should be checked to ensure that they have adequate capacity and that their channels are stable. Gullied, natural channels should be avoided where they are impractical to stabilize.

IMPORTANT
Design Tips

- Provide increased swale widths and flatter cross-sections if the swale must be crossed or maintained with large equipment.
- Provide 15 foot easements on either side of the swale to allow access by heavy equipment.
- A flow velocity of 1 foot per second (fps) will provide the greatest water quality benefit. Higher velocities are permissible for channel stability, but could result in resuspension of settled particulates. The maximum allowable Q_{10} velocity should be less than 3 fps.
- Provide a minimum of 2 feet of soil between the bottom of the swale and the top of an underdrain pipe, if used.
- Provide scour protection downstream of checkdams.
- Design check dams should be designed to infiltrate ponded water behind them within 12 hours.

8.1.3 Design and Construction Criteria

1. **Soils:** Soils should be suitable or be amended to establish a vigorous stand of vegetation. If dense vegetation cannot be maintained in the swale, its effectiveness will be severely reduced. Sites on A or B hydrologic group soils will be more effective for infiltration, although swales on other soils will still provide some treatment through sedimentation.

2. **Flow Duration:** To be effective in removing stormwater pollutants, swales must not be subjected to low flows of long duration and not kept wet for long periods. This will saturate the soil, and may kill the vegetation, reducing pollutant removal. The success of a swale system is enhanced by good stormwater treatment throughout its watershed. Good management practices reduce the peak

rate of runoff and the volume of water to be carried, infiltrated, or filtered by the waterway. Effective erosion control practices will limit the pollutant loading to the waterway.

3. **Equipment Access and Crossings:** If the swale or waterway must be crossed or maintained with large equipment, the width should be increased and flatter cross-section incorporated into the design. Large mowing equipment may require a significant increase in width over that needed for hydraulic capacity and freeboard. This problem deserves careful study in each project area so that the proper modifications are made in swale width and side slopes to meet the needs of equipment common to the locality. Easements of sufficient width to allow access by equipment (typically 15 feet minimum) must be provided on either side of the swale.

4. **Wildlife Habitat:** In order to increase the wildlife habitat potential of these systems, it is recommended that an additional, minimum 10-12 foot wide, no-mow buffer strip be incorporated into their design. This buffer strip should be located between the swale and developed areas, and could be planted with a variety of food-producing grasses/small shrubs and/or native wildflowers. This buffer can also serve as a physical separation from other lawn areas in order to discourage equivalent levels of mowing.

5. **Flow Velocity:** The channel should be designed for low velocity flow. A velocity of 1 fps is the maximum design storm flow velocity recommended when vegetated swales are being designed as a BMP. Higher velocities might be permissible for channel stability, but could result in resuspension of settled particulates. The maximum allowable Q10 velocity should be less than 3 fps.

6. **Flow Depth:** Flow depths in the swales should be minimized to increase the amount of vegetative filtering and settling. A maximum design flow depth of 1 foot is suggested. This will generally result in wide, shallow channel designs.

7. **Minimum Channel Dimensions:** The minimum width of the flat bottom of a trapezoidal channel shall be at least 3 times the channel depth. Non-trapezoidal channels should have similar depth to width relationships. Channel sideslopes shall not exceed 3 (horizontal):1 (vertical) for seeded or sodded slopes, or 2:1 for riprap slopes, although the channels may be parabolic or trapezoidal (Maryland, 1984). A vee-shaped swale is not recommended.

8. **Vegetation:** Vegetation for swale linings should be selected based on soils and hydrologic conditions at the site, in accordance with applicable Erosion and Sediment Control BMPs described in the Maine Erosion and Sediment Control BMPs, (2003). Recommended grasses include Ky-31 tall fescue, reed canary grass, redtop, roughstalked blue grass, and mixtures thereof (Galli, 1993).

9. **Construction Considerations:** Construct and stabilize the waterway in advance of any other channels or facilities that will discharge into it. Divert all flow from the waterway during the establishment period.

10. **Use with Check Dams:** The use of swales with check dams can enhance the pollutant removal efficiency. The following criteria should be followed when incorporating check dams into swales:

    a. <u>*Separation from Seasonal High Water Table & Bedrock:*</u> The recommended depth to seasonal high groundwater or bedrock for a swale using check dams is a minimum of 3 feet.

    b. <u>*Use with infiltration trenches:*</u> The use of swales with check dams can enhance the effectiveness of infiltration trenches when constructed above the trenches. The pool created by each check dam increases the volume of runoff infiltrated into the trench, while the vegetated swale helps to filter out suspended solids and other runoff pollutants. Refer to Chapter 6 Infiltration BMPs.

c. Alternative to curb and gutter design: Swales with check dams are excellent alternatives to conventional curb and gutter design for roadways and are generally less expensive to install, where road gradients and availability of land within or adjacent to the right-of-way allow.

d. Check Dam Design: The check dam should be constructed of durable rock or rock-lined material so that it will not erode. The area just downstream of the check dam should be protected from scour with properly designed rock riprap or protective channel lining. The check dam may have a solid level surface integrated into it for added durability. Check dam heights are generally 6 to 12 inches, depending on channel slope and desired storage capacity. The check dams should be notched or ported to allow the flows in excess of their infiltrative capacity to be bypassed. Check dams should be designed so that the water ponded behind them will infiltrate in 12 hours or less (Galli, 1993).

8.1.4 Maintenance

1. **Mowing:** Grass should not be trimmed extremely short, as this will reduce the filtering effect of the swale (MPCA, 1989). The cut vegetation should be removed to prevent the decaying organic litter from adding pollutants to the discharge from the swale. The mowed height of the grass should be 2-4 inches taller than the maximum flow depth of the design water quality storm. A minimum mow height of 6 inches is generally recommended (Galli, 1993).

2. **Routine Maintenance and Inspection:** The area should be inspected for failures following heavy rainfall and repaired as necessary for newly formed channels or gullies, reseeding/sodding of bare spots, removal of trash, leaves and/or accumulated sediments, the control of woody or other undesirable vegetation and to check the condition and integrity of the check dams.

3. **Aeration:** The buffer strip may require periodic mechanical aeration to restore infiltration capacity. This aeration must be done during a time when the area can be reseeded and mulched prior to any significant rainfall.

4. **Erosion:** It is important to install erosion and sediment control measures to stabilize this area as soon as possible and to retain any organic matter in the bottom of the trench.

5. **Fertilization:** Routine fertilization and/or use of pesticides is strongly discouraged. If complete re-seeding is necessary, half the original recommended rate of fertilizer should be applied with a full rate of seed.

6. **Sediment Removal:** The level of sediment deposition in the channel should be monitored regularly, and removed from grassed channels before permanent damage is done to the grassed vegetation, or if infiltration times are longer than 12 hours. Sediment should be removed from riprap channels when it reduces the capacity of the channel.

Selected References

Galli, John. 1993. *Analysis of Urban BMP Performance and Longevity*. Metropolitan Washington Council of Governments. Washington, D.C.

Maine DEP. 2003. *Maine Erosion and Sediment Control BMPs.* Bureau of Land and Water Quality and Maine Department of Environmental Protection.

Maryland Department of the Environment. 1984. *Maryland Standards and Specifications for Stormwater Management Infiltration Practices.* State of Maryland Department of the Environment, Sediment and Stormwater Administration. Annapolis, MD.

8.2 Flow Splitter (Flow Bypass)

8.2.1 Description

A flow splitter is an engineered structure used to divide flow into two or more directions. Its design uses specifically sized catch basins, pipes, orifices, and weirs set at specific elevations to control the direction of flow. Generally, a flow splitter will consist of a small storage area having one inlet and two outlets set at different elevations. The lower outlet is sized to convey low flows, such as the flow during a small storm or the flow at the beginning of a large storm. The higher outlet is sized to convey high flows that occur later in a larger storm. In this way, low flows can be conveyed to one area and high flows to another area.

The flow splitter has one primary purpose for stormwater management, which is to break up flows from a given storm for water quantity or water quality control.

Water Quantity Control - A flow splitter can be used to split runoff volume to alleviate downstream flooding due to development or it can also be used to prevent a BMP, such as a wet pond, from overtopping and eroding due to excessive runoff during large storms. This can reduce the needed storage capacity, reducing the cost of building the BMP.

Water Quality Treatment - A flow splitter can be used to separate the first flush volume from runoff later in the storm. By doing so, it keeps the first flush volume, which can contain most of the runoff pollutants, from being diluted by later runoff. This also allows a longer treatment time within wet ponds, extended detention wet ponds, and created wetlands. These BMPs depend on plug flow and long retention times to have efficient pollutant removal. Without a flow splitter, runoff later in the storm would push the first flush out the outlet before the pollutants are removed.

A basic example of a flow splitter is shown in Figure 8-2.

IMPORTANT

Flow splitters are used to divide flow into two or more parts; they do not provide any water quality treatment or quantity control. Flow splitters must be designed by someone familiar with hydraulics.

8.2.2 Design Criteria

Flow splitter design, to be effective, must be done by someone familiar with hydraulics. A badly-designed splitter can severely impede the function of the rest of the drainage system. The specific requirements for each design have to be done on a case by case basis. Only basic criteria are given below.

1. **Head Loss:** The flow splitter should be designed to minimize head loss by avoiding abrupt transitions in flows. Flow deflectors provide a gradual transition for flow and should be included in most designs

2. **Outlets:** The splitter must outlet to stable areas.

3. **Construction Considerations:** The functioning of a flow splitter depends on its construction as much as its design. Precise setting of elevations and grades are crucial to its performance. The splitter should be set using accurate leveling techniques by a licensed surveyor. "Eyeing-in" a splitter is not acceptable.

4. **Erosion Control:** Flow splitters built within drainage ditches may need additional armoring to withstand turbulent flows. The area where the flow will split should be well-protected with riprap or concrete.

5. **Access:** Because flow splitters involve a transition from larger pipes and channels to smaller pipes and channels, blockage is a

problem. Debris that flows freely into the splitter may block the splitter's outlets. Thus, access to the splitter for routine removal of debris is a necessity.

8.2.3 Maintenance

A flow splitter should be checked *regularly* and after every large storm to remove debris within the splitter.

Selected References

Urbonas B. and Stahre P. 1993. *Stormwater: Best Management Practices and Detention for Water Quality, Drainage, and CSO Management.* PTR Prentice Hall. Englewood Cliffs, NJ.

Water Environment Federation and American Society of Civil Engineers. 1992. *Design and Construction of Urban Stormwater Management Systems.* American Society of Civil Engineers. New York, NY.

8.3 Level Spreader

8.3.1 Description

A level spreader is a vegetated or mechanical structure used to disperse or "spread" concentrated flow thinly over a receiving area. Level spreaders reduce erosion and movement of sediment and also assist to filter sediment, soluble pollutants, and sediment-attached pollutants. They are generally used where concentrated flows are discharged to the ground and serve to convert the concentrated flow to sheet flow to prevent erosion of the downstream receiving area.

They are generally used to disperse flows over a relatively flat receiving area such as a buffer or swale to ensure uniform distribution of flow and minimize the channelization of water.

Level spreaders are not designed to remove pollutants from stormwater; however, some suspended sediment and associated phosphorus, nitrogen, metals and hydrocarbons will settle out of the runoff by settlement filtration, infiltration, absorption, decomposition and volatilization.

8.3.2 Site Suitability Criteria

1. **Drainage area:** The maximum drainage area to the spreader may not exceed 0.10 acre per foot length of level spreader lip if the level spreader is not discharging directly to a buffer and is only used to dissipate flow volume and velocity. The drainage area served by the spreader discharging directly cannot be more than half the size of the receiving buffer area.

2. **Slope:** The maximum slope of the receiving area below a level spreader should be no more than 30%. If the slope is greater than 30%, the discharge will need to be brought by a conduit and velocity dissipator to an area that is suitable.

IMPORTANT

This section discusses the design of a level spreader to convert concentrated flow to sheet flow to prevent erosion of downstream receiving areas and to lengthen time of concentration to reduce peak flows. The use of level spreaders with buffers for water quality purposes must follow the design criteria in Chapter 5 Buffers.

8.3.3 Design and Construction Criteria

These standards are not applicable for level spreaders discharging runoff to buffers used to meet the Department's General BMP Standards. Requirements for these level spreaders can be found in Chapter 5 for buffers.

1. **Discharge to a Level Spreader:** The peak stormwater flow rate to a level spreader due to runoff from a 10-year, 24-hour storm must be less than 0.25 cubic feet per second (0.25 cfs) per foot length of level spreader lip.

2. **Length of Level Spreader:** The level spreader length may not be more than 25 feet unless approved by the department.

3. **Siting of Level Spreader:** The level spreader must be sited so that flow from the level spreader will remain in sheet flow until entering a natural or man-made receiving channel.

4. **Capacity:** The capacity of each level spreader shall be based on the allowable velocity of the receiving soil. The flow area upstream of the level spreader shall be sufficient to ensure low approach velocities to the level "lip". The minimum flow area shall be equal to the flow area of the delivery channel.

5. **Buffer:** Each level spreader shall have a vegetated receiving area with the capacity to pass the flow without erosion. The receiving area shall be stable prior to the construction of the level spreader. The receiving area shall have a topography regular enough to prevent undue flow concentration before entering a stable watercourse but it shall have a slope that is less than 30%. If the receiving area is not presently stable, then the receiving area shall be stabilized prior to construction of the level spreader. This will limit construction to the growing season.

6. **Berm:** The berm of the level lip should consist of crushed rock with a three-quarter to three inches in diameter size gradation that will allow flows to slowly seep through the berm, a minimum of 18 inch high and 3 feet wide. The berm should have a 6 to 12 inch deep header channel with a 3-foot bottom width to trap sediments and reduce lateral flow velocities behind the berm. The bottom and back of the spreader channel should be lined with erosion control matting.

7. **Installation:** A level spreader must be installed correctly with 0% grade on the spreader base and lip to ensure a uniform distribution of flow; otherwise the structure may fail and become a source of erosion.

8. **Upstream Velocity:** The flow area upstream of the level spreader shall be controlled to ensure low approach velocities to the level "lip." The minimum flow area of level spreader shall be equal to the flow area of the delivery channel. The base and lip shall be installed at a 0% grade (level).

9. **Receiving Area:** Level spreaders shall blend smoothly into the downstream receiving area without any sharp drops or irregularities to avoid channelization, turbulence and hydraulic jumps. The receiving area below the level spreader shall be protected from harm during construction. Sodding and/or netting in combination with vegetative measures shall stabilize disturbed areas. The receiving area shall not be used by the level spreader until stabilization has been accomplished. A temporary diversion may be necessary in this case.

> **IMPORTANT**
> **Design Tips**
>
> • Level spreader length may not be more than 25 feet unless approved by DEP.
>
> • Flow leaving the level spreader must remain as sheet flow until entering a channel.
>
> • Level spreader must be installed with 0% grade on the spreader base and lip.

10. **Undisturbed Soils:** Level spreaders shall be constructed on undisturbed soil where possible.

11. **Entrance Drainage Channel Design:** The entrance channel to the level spreader is constructed across the slope and consists of a combination of stone and existing natural vegetation used to disperse, filter and lower the runoff velocity into the level spreader. The entrance channel shall blend smoothly into the downstream receiving area without any sharp drops or irregularities, so to avoid turbulence and hydraulic jumps.

   a. <u>Shape:</u> The entrance channel is typically trapezoidal in cross section, but may be parabolic as long as the soil bed design width is equivalent to the design bottom width for a trapezoidal section and is no more than 2 feet deep. Trenches shall be constructed along the existing contour and shall be 15-20 feet long and at least 7 feet wide across the top.

   b. <u>Bottom Width:</u> Bottom width for a trapezoidal cross section of the entrance channel should be a minimum of two feet.

   c. <u>Side Slopes:</u> Side slopes of the entrance channel shall be 2:1 or flatter to provide pretreatment of runoff entering the level spreader.

d. Longitudinal Slope: The longitudinal slope of the entrance channel should be 1% grade or less in order to avoid excessive velocity and deep water at the downstream end when ponding. If topography dictates a steeper net channel slope, the swale can be broken into relatively flat sections by check dams placed at no closer than 50 feet intervals.

e. *Depth and Capacity:* The swale should be designed to safely convey the 2 year storm with design velocities less than 4.0 to 5.0 feet per second. The swale should have sufficient total depth to convey the 10-year storm with 6 inches of freeboard.

8.3.4 Maintenance

Long term maintenance of the level spreader is essential to ensure its continued effectiveness. The following provisions should be followed. In the first year the level spreader should be inspected semi annually and following major storm events for any signs of channelization and should be immediately repaired. After the first year, annual inspection should be sufficient. Vegetated level spreaders may require periodic mowing. Spreaders constructed of wood, asphalt, stone or concrete curbing also require periodic inspection to check for damage and to be repaired as needed.

1. **Inspections:** At least once a year, the level spreader pool should be inspected for sand accumulation and debris that may reduce its capacity.

2. **Maintenance Access:** Level spreaders should be sited to provide easy access for removal of accumulated sediment and rehabilitation of the berm.

3. **Sediment Removal:** Sediment build-up within the swale should be removed when it has accumulated to approximately 25% of design volume or channel capacity. Dispose of the sediments appropriately.

4. **Debris:** As needed remove debris such as leaf litter, branches and tree growth from the spreader.

5. **Mowing:** Vegetated spreaders may require mowing.

6. **Snow Storage:** Do not store snow removed from the street and parking lot within the area of the level spreader.

7. **Level Spreader Replacement:** The reconstruction of the level spreader may be necessary when sheet flow from the spreader becomes channeled into the buffer.

Selected References

Maine DEP. 2003. *Maine Erosion and Sediment Control BMPs.* Bureau of Land and Water Quality and Maine Department of Environmental Protection.

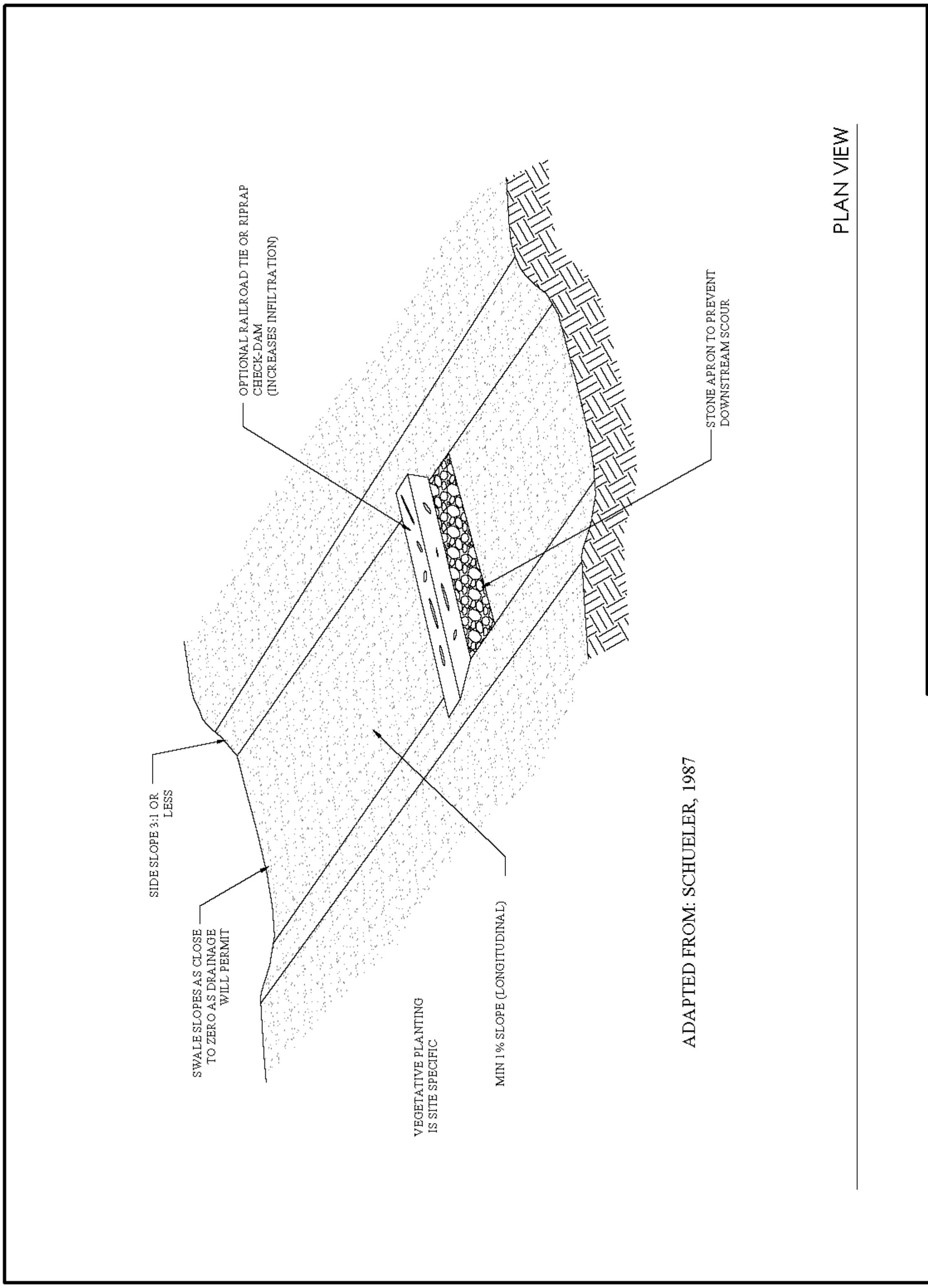

FIGURE 8-1. TYPICAL SWALE WITH CHECKDAMS

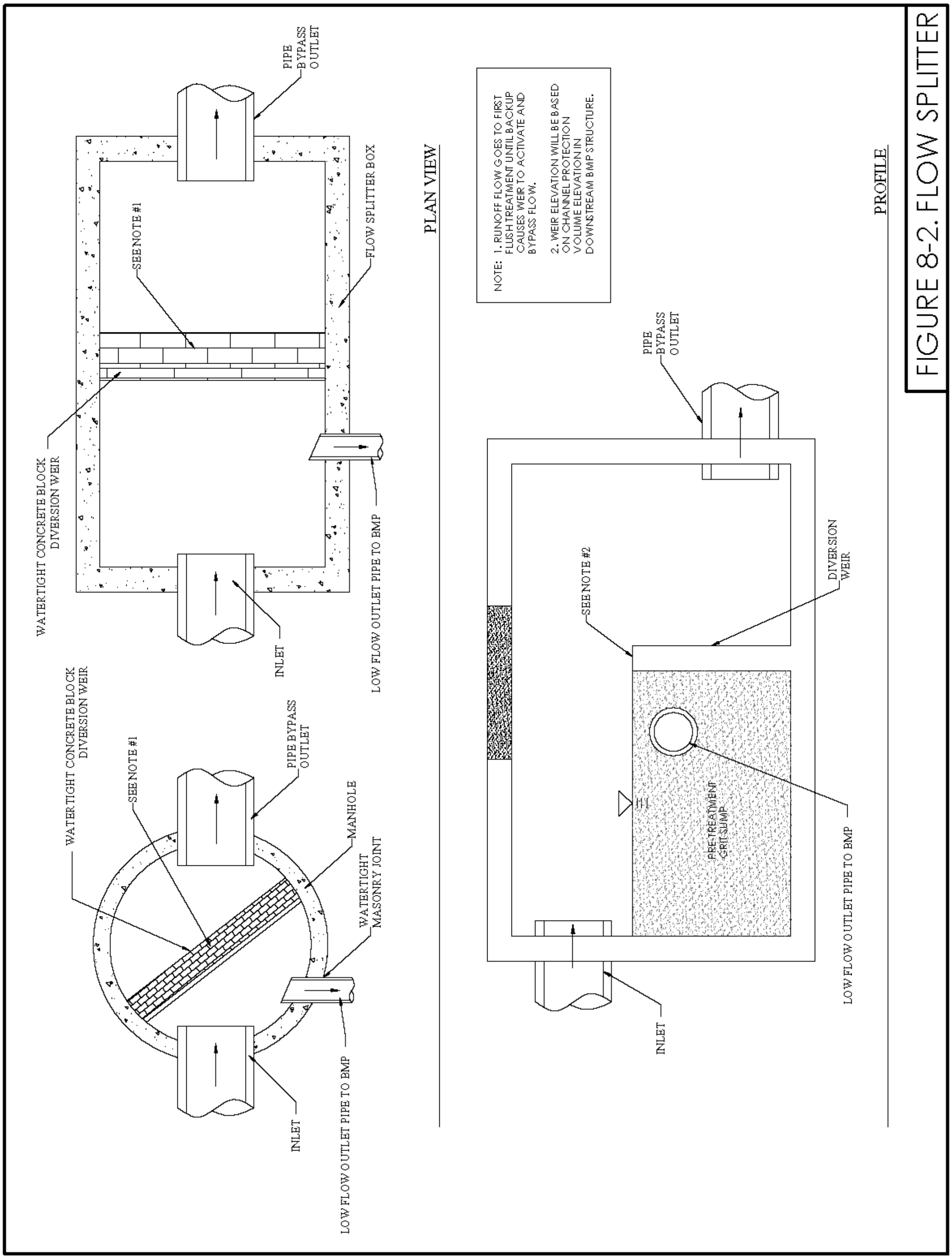

FIGURE 8-2. FLOW SPLITTER

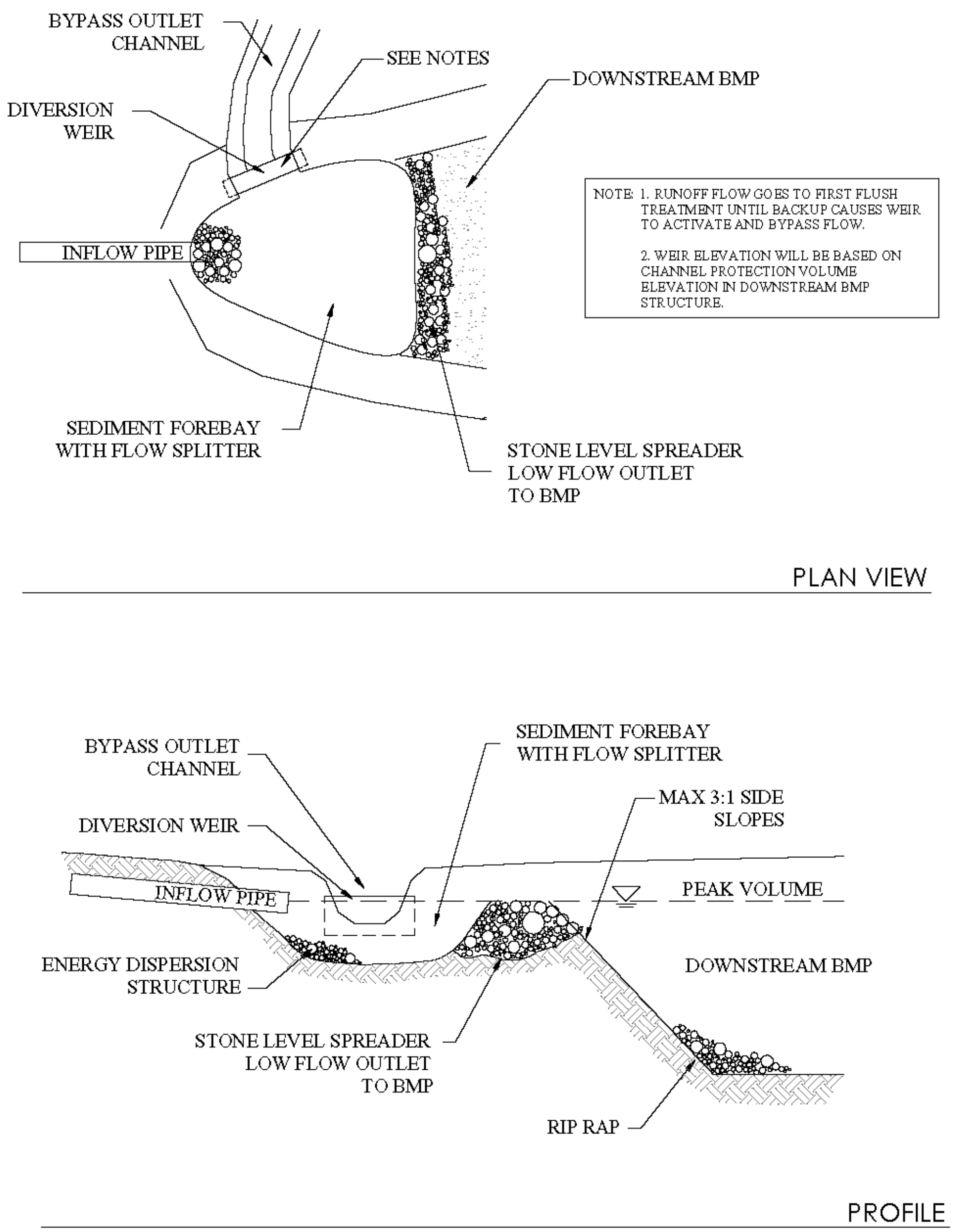

FIGURE 8-3. TYPICAL SURFACE FLOW SPLITTER IN FOREBAY